recycling

MDPI

Article

Reforming Construction Waste Management for Circular Economy in Kazakhstan: A Cost–Benefit Analysis of Upgrading Construction and Demolition Waste Recycling Centres

Ferhat Karaca * and Aidana Tleuken

School of Engineering and Digital Sciences, Nazarbayev University, Astana 010000, Kazakhstan; aidana.tleuken@nu.edu.kz

* Correspondence: ferhat.karaca@nu.edu.kz; Tel.: +7-7172-704553; Fax: +7-7172-706054

Abstract: This paper investigates the advantages of enhancing construction and demolition waste (CDW) recycling facilities to conform to circular economy (CE) models in Kazakhstan's construction sector. The industry is experiencing significant growth due to urbanization, but it faces difficulties managing CDW, frequently resulting in landfill disposal. In response, this paper provides a cost–benefit analysis of upgrading the CDW recycling centres aligned with CE needs. Reflecting legislative changes in Kazakhstan's Environmental Code, which prohibited CDW in landfills starting December 2020, the initiative to establish modern CDW recycling centres is gaining momentum in major cities. The primary objective is to maximize material recovery and eliminate contaminants that curtail the utilization of recycled sand and aggregate products. The analysis yields compelling results, indicating that the project has the potential to recycle up to 84 million tons of CDW over eight years, with an annual 25% capacity increase and a maximum possible 95% recycling efficiency. Despite an estimated cost of USD 48 million, the project demonstrates a payback period of 9.9 years, signalling eventual cost recovery. These findings underscore the project's capacity to mitigate CDW issues while generating economic benefits and contributing to a sustainable environment. In conclusion, implementing modern CDW recycling centres in Kazakhstan represents a potent solution for the construction industry as it transitions toward a CE model. This transition addresses both pressing environmental challenges and promising economic prospects.

Keywords: CDW; SDGs; waste management; recycling; contraction value chain; Central Asia

check for updates

Citation: Karaca, F.; Tleuken, A. Reforming Construction Waste Management for Circular Economy in Kazakhstan: A Cost–Benefit Analysis of Upgrading Construction and Demolition Waste Recycling Centres. *Recycling* **2024**, *9*, 2. https://doi.org/10.3390/recycling9010002

Academic Editor: Domenico Asprone

Received: 15 November 2023
Revised: 10 December 2023
Accepted: 22 December 2023
Published: 29 December 2023

1. Introduction

In order to achieve a net-zero and climate-resilient economy, significant investments are required in all sectors of society, including the construction sector as a leading economic driver of developing economies. Collaboration between public and private actors is necessary to direct financial flows into the green finance system and create frameworks and tools [1].

One of the major environmental challenges facing us is transitioning from a linear take-make-waste model to a circular economy (CE) that minimizes waste and maintains resources at their highest value throughout their lifespan. The CE offers a solution to climate change and other environmental issues by aiming to restore and regenerate ecosystems [2]. However, scaling up these models and innovations requires new investments and financial instruments.

Circular models within the construction industry present a promising concept in emerging economies. These models aim to maintain the value of materials and structures for as long as possible and have significant growth potential in the short-to-medium term, driven by policies, regulations, and evolving customer preferences [3].

The construction industry in Kazakhstan is rapidly growing thanks to the country's fast-paced urbanization process. For the last 15 years, the volume of construction works and construction materials production has increased around three times [4]. While some recycling practices have been established in the construction sector, there are still significant gaps from a CE perspective [5]. Proper construction and demolition waste (CDW) management remains a challenge, with waste often ending up in landfills [6]. Construction firms are currently dealing with challenges, emphasizing that Kazakhstan lacks comprehensive regulations concerning the management of CDW, thereby giving rise to concerns related to the storage and disposal of such waste materials. The act of prohibiting disposal was enacted without accompanying guidance, thereby compounding the issue of unregulated informal waste sites in Kazakhstan, as exacerbated by the implementation of the Eco Codex [7]. Additionally, there is a need for strategies and protocols to incorporate the CE model into the sector.

By addressing these gaps, this paper proposes a cost–benefit analysis of a CE implementation project based on stakeholder needs in Kazakhstan. The Environmental Code in Kazakhstan was amended in 2016 to extend the list of waste types that are not permitted in landfills. Consequently, as of December 2020, CDW is no longer permitted in landfills, and municipalities in large cities have established new landfill sites specifically for CDW. However, the current technology in these cities' shredders is outdated and unsuitable for effective recycling. To address this issue, plans are underway to establish new CDW recycling centres in the newly installed polygons in large cities, focusing on the best practices to maximize CDW recycling.

This study aims to analyze the implementation of modern CDW recycling centres, focusing on maximizing material recovery and removing contaminants that would otherwise restrict the final destination for the recycled sand and aggregate products. The objective of this study is to establish a cost–benefit assessment for installing modern CDW recycling centres in the major cities of Kazakhstan (i.e., Almaty, Astana, and Shymkent) in response to the evolving regulatory framework and the pressing need to address the challenges associated with CDW management.

2. Results and Discussions

2.1. Kazakhstan's Circularity Baseline for CDW Management

Firstly, an investigation was conducted to determine the level of circularity in CDW in Kazakhstan. This analysis compared the CDW treatment plans in Kazakhstan [8] with those of European Union countries (EU28) [9,10]. Regrettably, the results indicated that many indicators pertinent to secondary raw materials (SRM), innovation, and green jobs are not being developed in Kazakhstan. This has resulted in a lack of statistical indicators or proxies available to measure progress in these areas. To accurately assess the CE baseline in Kazakhstan, several indicators under the green growth framework are required. These include waste generation intensity and recovery ratios, the share of renewable energy sources, demand-based CO_2 productivity, and carbon productivity based on demand.

The recovery rate of CDW in the construction sector across EU-28 countries was found to be impressive (up to 90%) [11]. However, in Kazakhstan, this rate is only a minuscule 2.96% [5]. One of the key principles of the CE is to design waste and pollution out of the system. Therefore, CE strategies must aim to reduce and recycle CDW production while simultaneously promoting the creation of closed-loop systems to manage this resource effectively.

Kazakhstan's "Green Taxonomy" [12] includes "green buildings" as a distinct classification, underscoring the strategic importance of adopting sustainable technologies in the construction sector. The taxonomy refers to international construction standards such as LEED, BREEAM, EDGE, and DGNB as benchmark indicators.

2.2. Kazakhstan's Construction, Renovation, and Demolition Waste Management Activities

CDW is a diverse category that covers numerous materials, such as concrete, bricks, wood, glass, metals, and plastic. CDW also encompasses waste generated from the construction and demolition of buildings, infrastructure, road planning, and maintenance.

While some components of CDW have high value, others can be reprocessed into new products or materials. Interestingly, recent research indicates that, on average, 95% of these materials are stored in buildings, while the remaining 5% end up in landfills [13]. Separating and recovering CDW is a well-established, readily available, and generally inexpensive process (Figure 1). However, hazardous materials such as solvents and asbestos can threaten the environment and require certain recycling efforts if not separated at the source.

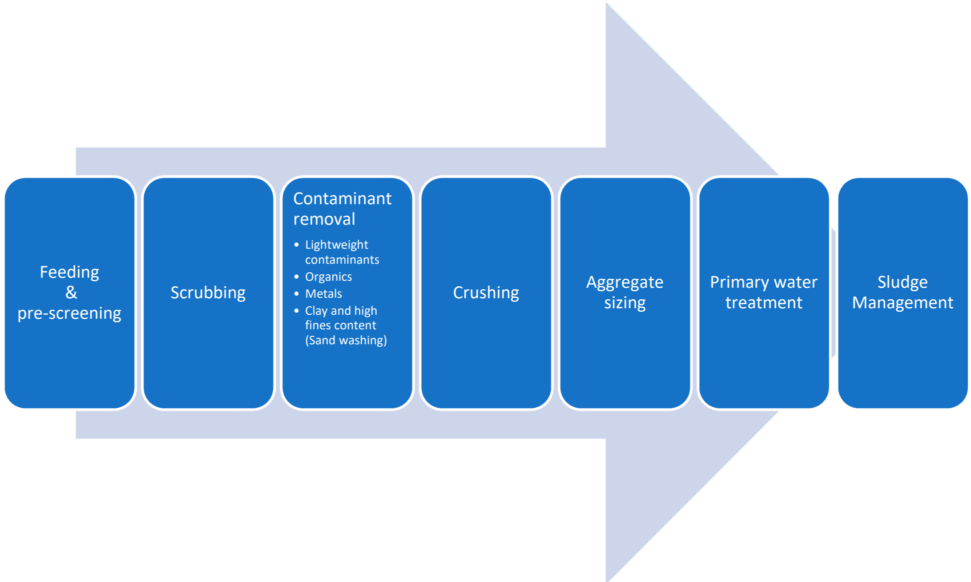

Figure 1. Operations for a modern CDW recycling plant.

Table 1 provides an overview of the estimated amount of waste generated in Kazakhstan in 2019, classified according to low- and high-value recovery potential. Nevertheless, Kazakhstan has not established a monitoring, recycling, or material recovery system for CDW. Since the material flow data for waste streams are unreliable, these estimations were made based on the material inputs to the sector, which were reported by national statistics [14].

Table 1. CDW generated in renovation and demolition activities by waste type category.

Waste	kt	Percentage of the Total Construction Waste
Low-value waste	8324	92.5%
High-value waste	234	2.5%
Non-recoverable waste	451	5%
Total	9009	100%

2.3. *Cost–Benefit Assessment*

The foundation of this project was laid upon the amendments made to the Environmental Code of Kazakhstan in 2016, which expanded the list of prohibited waste types in landfills, including CDW. As of December 2020, the disposal of CDW in conventional landfills was banned, leading to the establishment of specialized landfill sites for CDW by the municipal authorities, or Akimats, in major cities such as Astana and Almaty. During stakeholder consultations with landfill managers and representatives from the construction department, it became evident that the existing shredding technologies at these landfill sites were outdated and inadequate for effective recycling. The urgent need for new CDW recycling centers was identified to enhance recycling capabilities and maximize material recovery from CDW.

The project requires several key activities, some of which are not covered in this paper. These include identifying appropriate sites for constructing CDW recycling centres, selecting advanced recycling technologies tailored to CDW, and physically establishing these centres. The project aims to achieve several quantitative milestones, with the program implementation year (8 years) being a crucial one. Over a period of eight years, approximately 84 million tonnes of CDW will be recycled. The recycling operations will have a consistent annual capacity increase of 25%. Full-cycle CDW recycling centers will be successfully installed in eight major cities. The recycling process will achieve an impressive 95% efficiency rate.

To measure the effectiveness of the upgrades made to the CDW recycling centres, we utilized the annual amount of CDW recycled as the primary key performance indicator (KPI). This selection was made to establish a tangible and measurable means of monitoring progress toward our objectives and to fulfil the expectations of our stakeholders. By focusing on this specific metric, we can ensure that our efforts are concentrated on achieving our desired outcomes and that we can assess the impact of our initiatives accurately. The success of this endeavour was contingent upon the collaboration of various key stakeholders, including construction companies, Akimats (municipal authorities), landfill polygons (specialized landfill operators), regulatory governance bodies, supporting actors, and other related industries. These stakeholders were crucial in providing resources, expertise, and support throughout the project lifecycle. The key implementers of this project were the Akimats and landfill polygons. They were responsible for overseeing the construction and operation of the recycling centres, ensuring compliance with regulations, and facilitating the smooth execution of recycling activities.

The amount of construction, renovation, and demolition waste in Kazakhstan varies depending on the type of interventions and projects. For instance, the government plans to invest in 112 infrastructure projects worth KZT 5.5 trillion by 2025 [15]. This includes constructing and reconstructing 10,000 km of roads and repairing 11,000 km of the road network throughout the country. The Nurly Zhol (https://idfrk.kz/en/products/state-programs/nurly-zhol-2020-2025/) (accessed on 1 August 2023) initiative also allocates USD 9 billion to develop and modernize the country's roads, railways, ports, airports, and IT infrastructure. Moreover, due to rapid urbanization, new construction is prioritized over re-urbanization activities. In Kazakhstan, CDW primarily originates from construction and renovation activities. Therefore, the country needs to focus on enhancing the design of construction projects; selecting more sustainable, durable, easy-to-maintain, and highly recyclable materials; and adopting sustainable production techniques. This approach will encourage a more circular value chain, promoting a more eco-friendly and sustainable environment.

The initial investment required for the CDW recycling renovation program (including assembling and commissioning): The installation cost of modern recycling encompasses the investment needed for facilities and infrastructure. A cost–benefit analysis was conducted for a large city context, estimating costs for eight active construction cities in Kazakhstan. The initial investment estimate was based on similar projects in the EU and obtained by direct communication with similar project holders, such as CDE RECO Solutions in Norway. The initial investment required to set up a recycling plant in Kazakhstan was estimated to be USD 5 million. It is proposed that these plants have a high capacity and the ability to process up to 300 tons of waste per hour.

According to the data obtained from Nur-Sultan landfill management during stakeholder engagement activities, it has been estimated that around 8.5 thousand tonnes of waste were received in the last three months of 2021, which translates to approximately 35 thousand tonnes per year. The total amount of waste generated in the country is estimated to be 9 million tonnes. Notably, landfilling is not allowed in the Ecological Code of the Republic of Kazakhstan. Therefore, 80% of the waste is expected to be sent to recycling centres, based on the EU's objective to recycle 80% of construction and demolition waste. Additionally, there is a projected 25% annual increase in the total amount of waste collected annually.

The aim of the plants is to achieve an efficiency rate of 75% while recycling 84 million tons of waste in eight years. To achieve this goal, eight such plants will be required. Each of these eight plants is assumed to operate for 220 working days per year. The recycling process is expected to be carried out safely and in an environmentally friendly manner using modern technology and equipment (Figure 1) to ensure that the recycling process is efficient and effective.

The percentage distributions of the costs are illustrated in Figure 2. The reinvestment requirements are assumed to be 1% of the annual investment cost. Operating costs include administrative costs of project and service provision and are estimated to be the same as the reinvestment cost, adding another 1% on top of the project cost per year. Operating costs are estimated based on the required personnel and average wage payments. The technical requirements include support from the service technology providers and consultation, along with other expenses for research and development, which is also estimated to be USD 400,000 in total for the program implementation time.

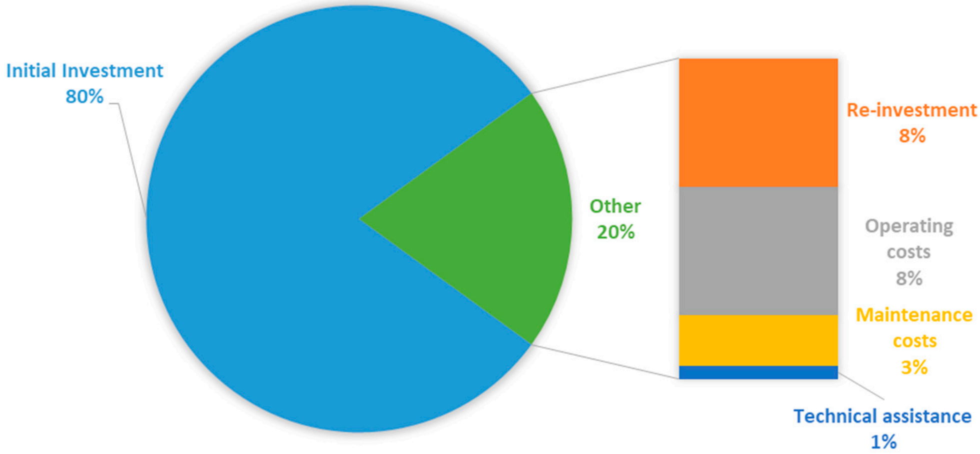

Figure 2. The percentage distributions of the costs.

Benefits (cost saving for construction/demolishing through recycling rather than landfilling): The primary output of CDW recycling operations is mostly aggregate, which can replace virgin materials in various sectors. This is an essential aspect of the project, as it helps conserve natural resources and reduces the need to extract and transport virgin materials. The recycled products generated from CDW have a considerable commercial value, which is a significant monetary benefit of the project. For instance, the selling price for gravel and similar products in the region is approximately USD 10 per ton, assuming a 95% recovery rate based on current experience in the polygons. This means that the project has the potential to generate considerable revenue, making it a viable and sustainable solution for waste management. The calculated cash flow of the project is illustrated in Figure 3.

The key findings of this research indicate a potential to recycle up to 84 million tons of construction and demolition waste (CDW) over ten years, resulting in an annual 25% national capacity increase in recycling (Figure 4). Moreover, installing full-cycle CDW recycling centres in major cities will ensure up to 95% recycling efficiency. A net cost-discounted evaluation of the project has been calculated, which shows that the project would cost approximately USD 48 million. The project's cost–benefit ratio is 0.59, indicating that its costs exceed its benefits. The payback period is estimated to be 9.91 years, indicating that the initial investment will be recovered within this period. Overall, these findings highlight the potential of the project to reduce CDW and contribute to a more sustainable environment while generating economic benefits for the stakeholders involved.

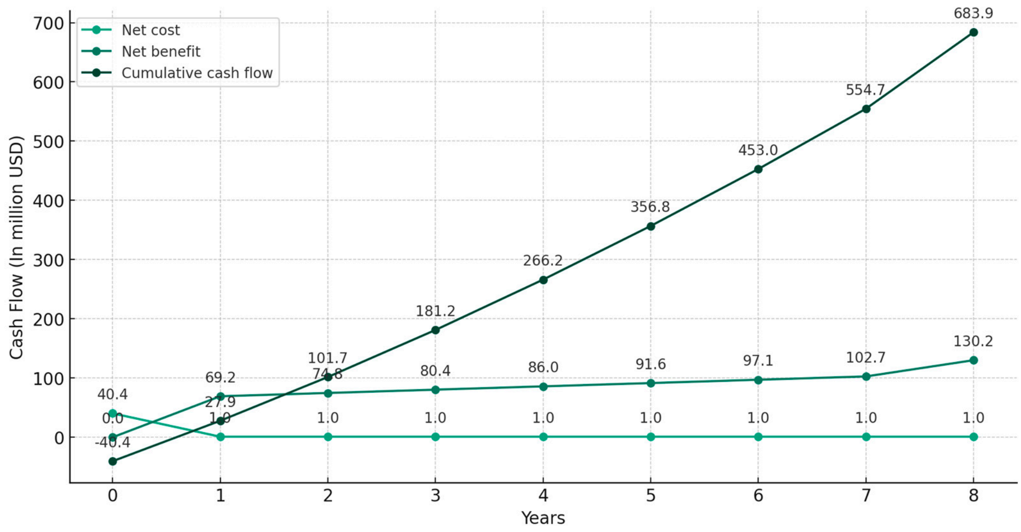

Figure 3. The cash flow of the project.

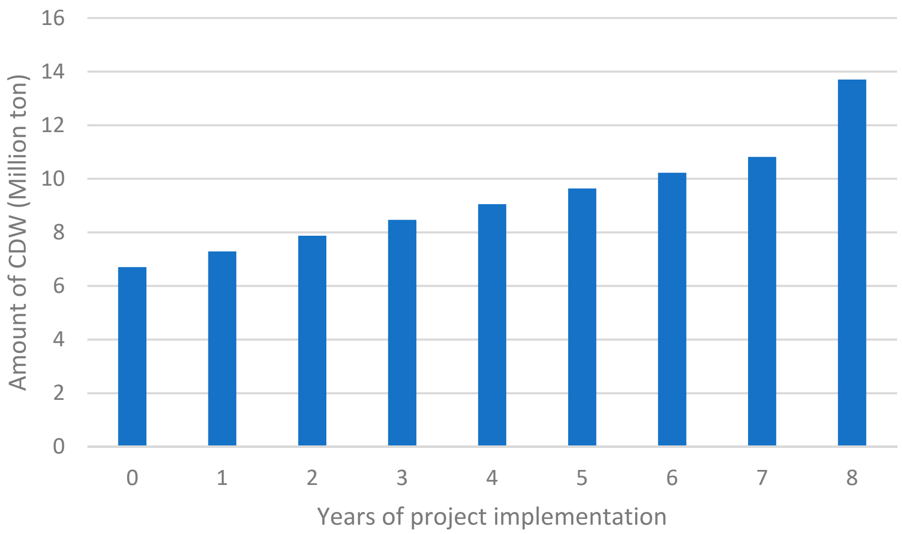

Figure 4. Annual potential of CDW recycling.

2.4. Co-Benefits Assessments

In the quest for sustainable development and responsible waste management practices, upgrading CDW recycling centres in KZ has undergone a comprehensive cost–benefit analysis. This analysis assesses the positive impacts and ancillary benefits this project will bring to Kazakhstan's communities, environment, and economy. The primary objective of this project is to achieve a substantial reduction in waste through the recycling of low-grade CDW generated in major cities. Over eight years, this translates to diverting a significant 84 million tons of CDW from traditional landfill disposal. This achievement represents a remarkable commitment to sustainable waste management practices, effectively addressing environmental concerns associated with waste accumulation. While precise national-level data on energy reduction are currently unavailable, a qualitative assessment reveals the potential for significant energy savings. The project's assumption that recycled CDW, specifically gravel, requires significantly less energy for production strongly indicates its energy-efficient approach. By potentially reducing energy requirements by up to 72% compared to raw material production, the project aligns with broader sustainability goals and showcases its potential to enhance energy conservation within the construction sector.

The project's impact on pollution reduction associated with raw construction material production is notably high, even in the absence of precise national-level data. By targeting reductions in related greenhouse gas (GHG) emissions by up to 70%, resulting in a quantified reduction of 2.6 ktCO2e and a significant decrease in photochemical smog production by up to 87%, the project underscores its commitment to mitigating environmental pollution. These reductions translate to improved air quality, reduced environmental harm, and potential health benefits for the populace, underlining its substantial positive environmental impact.

The project's emphasis on recycling CDW generates an environment conducive to job creation. While precise national-level employment data are currently unavailable, establishing recycling centres, logistical operations, and emerging new markets for recycled materials is anticipated to result in high employment opportunities. This aligns with the project's overarching goal of stimulating local economic development and providing increased livelihood prospects for the community. While the economic impact on a sectoral level is categorized as moderate, this project significantly contributes to enhancing the competitiveness and sustainability of the construction sector. Recycling CDW offers a more sustainable and cost-effective alternative to raw material usage in construction.

Although the cost differential may not be highly significant for contractors, the project's additional benefits, such as reduced environmental impacts and enhanced resource efficiency, underscore its vital role in promoting a more competitive and environmentally responsible construction industry.

2.5. Financial Options for the Project Implementation

The upgrading project for the CDW recycling centres in Kazakhstan is estimated to cost USD 48 million. To fund this initiative, a combination of financing options has been proposed. The primary funding source is private-sector financing, which will be facilitated through a public–private partnership (PPP) arrangement. Additionally, the municipality will provide the land required for the project. The funding plan is summarised in Figure 5, and the implementation period is suggested to be 1 to 4 years.

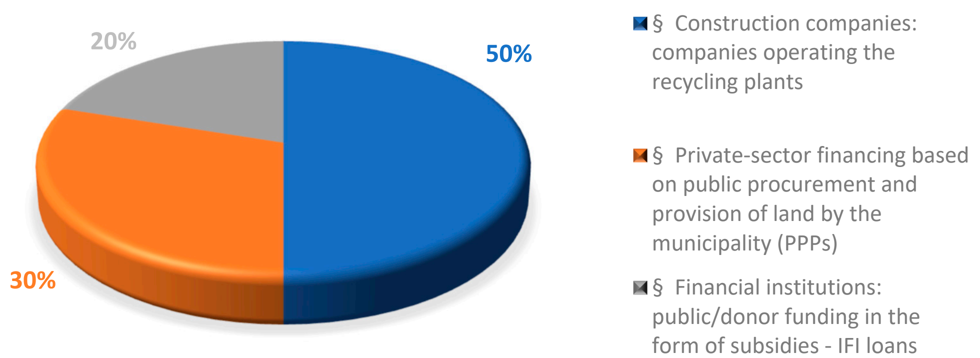

Figure 5. Financing options for upgrading projects for the CDW recycling centres in Kazakhstan.

It is suggested that the project's funding strategy allocates a significant portion, up to 30%, to private-sector financing through a PPP model. This approach involves collaboration between the public sector (municipality) and private investors, leveraging the strengths of both sectors to secure the necessary funds. This allocation aligns with best practices for infrastructure development projects, where private sector involvement can contribute expertise, capital, and operational efficiency. The project's reliance on the municipality for the provision of land is a practical approach, as it reduces the initial capital burden on the project. The municipality's land allocation reduces costs and ensures that suitable sites are made available for the recycling centre's construction. The project's implementation period spans from Years 1 to 4. This timeline is reasonable for the development of a large-scale CDW recycling centre. It allows for careful planning, design, and construction and the initiation of operational activities within a realistic timeframe. The inclusion of private-sector financing through a PPP model indicates a commitment to leveraging private investment and expertise in waste management. This approach can lead to efficient project execution, improved technology adoption, and potentially reduced financial risks for the municipality. While the initial capital investment is substantial, it is essential to consider the long-term financial sustainability of the recycling centre. Revenue generation from recycling operations, cost recovery mechanisms, and potential income streams from recycled materials should be evaluated to ensure the project's financial viability beyond the implementation period. The PPP model can help mitigate certain project risks, such as construction delays, operational challenges, and cost overruns, by sharing responsibilities and risks between the public and private sectors. A well-structured PPP agreement should address risk allocation and dispute resolution mechanisms. During the implementation period, close monitoring and accountability mechanisms should be in place to ensure that funds are utilized efficiently and per the project's objectives. Transparent financial reporting and performance evaluation will be critical.

2.6. Comparison with Neighbouring Countries

In addition to presenting the implementation of CDW recycling centers in Kazakhstan, this study expands its scope to include a comparative analysis with other Central Asian countries such as Uzbekistan, Kyrgyzstan, Turkmenistan, and Tajikistan. This comparison can be helpful in understanding the broader applicability of the findings developed in this study.

In Uzbekistan, recycling rates are claimed to be in their nascent stage; around 23% of total waste is recycled (including CDW) [16,17], while the waste management strategy aims for 60% to be recycled. The recent agreement on waste-to-energy plants and other waste treatment initiatives [18] demonstrates the country's readiness for the adoption of CDW sustainable initiatives and significant recycling market potential, similar to Kazakhstan. While social commitment to sustainable waste practices is active in Kyrgyzstan, governmental legislative actions do not clearly state recycling rates and CDW recycling goals [19,20].

Similarly, there are no clear statistics concerning the recycling rates of construction waste in Turkmenistan and Tajikistan, nor the countries' waste recycling goals. The data on specific facilities for CDW recycling in Central Asian countries and, particularly, recycling centers is either limited (e.g., in Uzbekistan) or not readily available. In general, disparities in the application and execution of legal and regulatory frameworks among Central Asian countries, influenced by variations in socioeconomic status, lead to uneven enforcement capabilities of legal and regulatory measures [21].

Thus, the cost–benefit assessment of upgrading CDW recycling centers in Kazakhstan can benefit the whole Central Asian region by providing information for sustainable waste management practices and catalyzing positive environmental changes across the region. The implementation process can provide valuable insights for other countries with similar backgrounds, especially from the Central Asian region.

3. Materials and Methods

Cost–benefit analysis is a widely used methodology that involves identifying the necessary activities for implementing a project. This methodology aims to evaluate the project's social costs and benefits in monetary terms. Essentially, the process involves defining a timeframe for implementation and benefit acquisition. Once these values have been identified, they are discounted to the present using a discount rate. This approach allows decision-makers to fully understand the implications of the proposed measure and make informed decisions based on a thorough analysis of the costs and benefits involved. The key components of this methodology include identifying costs and benefits, assigning monetary value to those costs and benefits, and discounting these values to account for the time value of money. By following these steps, cost–benefit analysis can provide valuable insights into the potential impacts of a proposed measure and help ensure that resources are allocated as effectively and efficiently as possible [22].

In order to accurately evaluate the potential success of a given project (upgrading CDW recycling centres in large cities in KZ), it is imperative to conduct a comprehensive analysis of the associated costs and benefits. This includes identifying and outlining the types of costs and benefits that will be incurred and determining when they will occur over the course of the project's lifespan (i.e., eight years) in KZ. One of the key components of this analysis is carefully examining the costs incurred in implementing the various measures associated with the project. This includes an assessment of the resources required to carry out each measure and a consideration of any other relevant factors that might impact the cost of implementation.

In addition to assessing the implementation costs, it is also important to carefully evaluate the potential benefits that a given project might generate. This can be a more complex task, particularly when monetizing those benefits. For instance, positive outcomes may take the form of avoided costs over the medium and long term, such as reduced healthcare expenditures or increased productivity.

This study follows a more quantitative method and relies on assumptions and estimation to assign values and estimate these benefits. The initial cost–benefit analysis is conducted with consideration given to the characteristics presented in Table 2.

Table 2. Parameters considered to perform a cost–benefit analysis for CDW recycling centers.

Costs	Benefits	Co-Benefits
Initial investment Reinvestment Operating costs Maintenance costs Costs of technical assistance	Revenues/Incomes	Waste reduction Energy reduction Pollution reduction GHG emissions reduction Job opportunity creation Economic impact on a sectoral level Efficiency improvement

When computing the net present values of expenses and profits, it is crucial to establish a discount rate. This rate was taken from the World Bank (i.e., 11.08%) [23]. The net present value should be factored in the yearly expenses and profits of the project and updated financially utilizing discount rates. The formula for doing so is as follows (1):

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} - C_0 \quad (1)$$

where t represents the implementation period, C_t is the cash flow (expenses–profits) for the given period, r is the discount rate, and C_0 is the net initial investment expenditure. The payback period is the number of years it takes to recover the project's initial investment. To determine the benefit–cost ratio, it is necessary to compare the net present expenses with the net present profits. A ratio greater than 1 indicates that the net present profits outweigh the costs and that the project is economically feasible. If the ratio is negative (<1), the costs are higher than the profits.

In addition, a comprehensive assessment of the consequences of its measures on various aspects, such as social, environmental, and macroeconomic factors, is conducted. The outcomes are then extrapolated to a national level to analyze their impact on the country. The evaluation process considers quantitative and qualitative benefits such as reducing waste and pollution, decreasing greenhouse gas emissions, creating jobs, and enhancing competitiveness based on expert opinions. To perform the calculation as suggested in this methodology, we developed an Excel-based cost and benefit calculation tool and shared it as Supplementary Material.

4. Conclusions

In conclusion, implementing modern CDW recycling centres in Kazakhstan presents a promising solution to address the challenges the construction industry faces in transitioning to a CE model. The findings reveal a significant contrast in the recycling rates of CDW between Kazakhstan and European Union countries, with Kazakhstan's rate at a mere 2.96% compared to up to 90% in the EU. This discrepancy highlights the significant opportunities for Kazakhstan to enhance its CDW recycling efforts.

The establishment of CDW recycling centers in major cities of Kazakhstan represents a pivotal step in addressing the growing challenges associated with CDW management. The project's quantitative results and key performance indicators demonstrate its effectiveness in achieving its goals, thereby contributing to a more sustainable and environmentally responsible construction industry in Kazakhstan. The collaboration of various stakeholders and the commitment of implementers were instrumental in realizing the project's objectives and maximizing the CDW recycling potential. The proposed funding options and implementation period for the CDW recycling centres in Kazakhstan appear to be well-considered. The cost–benefit assessment conducted in this study of upgrading CDW recycling centres in Kazakhstan reveals that while the project costs (USD 48 million) initially exceed its benefits, with a cost-benefit ratio of 0.59, the payback period is estimated to be under ten years. This indicates that the long-term benefits, both environmental and economic, are significant.

The study also signifies the importance of adopting circular economy approaches in construction waste management through relevant legislative actions, strategies, and financial incentives. The utilization of private-sector financing and a PPP model, coupled with land provision by the municipality, is a strategic approach to secure the necessary resources for the project. However, careful financial planning, risk management, and a focus on long-term financial sustainability will be essential to the project's overall success. Ongoing monitoring and accountability will ensure that the project stays on track and delivers its intended benefits to the community and the environment.

The co-benefit analysis of upgrading the CDW recycling centres in KZ elucidates its potential to have substantial positive impacts encompassing waste reduction, energy conservation, pollution reduction, job creation, and sectoral competitiveness. These outcomes exemplify the project's commendable commitment to sustainable development and responsible waste management practices, positioning it as a pivotal initiative for improving Kazakhstan's communities, environment, and economy.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/recycling9010002/s1.

Author Contributions: Conceptualization, F.K.; methodology, F.K.; investigation, F.K. and A.T.; writing—original draft preparation, F.K.; writing—review and editing, A.T.; supervision, F.K.; project administration, F.K.; funding acquisition, F.K. All authors have read and agreed to the published version of the manuscript.

Funding: The authors acknowledge the financial support from the Nazarbayev University Collaborative Research Program (Funder Project Reference: 20122022CRP1606).

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Nyangchak, N. Emerging green industry toward net-zero economy: A systematic review. *J. Clean. Prod.* **2022**, *378*, 134622. [CrossRef]
2. Möslinger, M.; Ulpiani, G.; Vetters, N. No TitleCircular economy and waste management to empower a climate-neutral urban future. *J. Clean. Prod.* **2023**, *421*, 138454. [CrossRef]

3. Guerra, B.C.; Leite, F. Circular economy in the construction industry: An overview of United States stakeholders' awareness, major challenges, and enablers. *Resour. Conserv. Recycl.* **2021**, *170*, 105617. [CrossRef]
4. Kazakhstan., P.P. service of the P. M. of the R. of Kazakhstan. "In Kazakhstan, the Volume of Production of Building Materials Increased 3.3 Times," *PrimeMinister.Kz.*, 2020. [Online]. Available online: https://primeminister.kz/ru/news/v-kazahstane-obem-proizvodstva-stroitelnyh-materialov-uvelichilsya-v-33-raza-miir-rk-2161319 (accessed on 5 April 2023).
5. Tokazhanov, G.; Galiyev, O.; Lukyanenko, A.; Nauyryzbay, A.; Ismagulov, R.; Durdyev, S.; Turkyilmaz, A.; Karaca, F. Circularity assessment tool development for construction projects in emerging economies. *J. Clean. Prod.* **2022**, *362*, 132293. [CrossRef]
6. Torgautov, B.; Zhanabayev, A.; Tleuken, A.; Turkyilmaz, A.; Mustafa, M.; Karaca, F. Circular Economy: Challenges and Opportunities in the Construction Sector of Kazakhstan. *Buildings* **2021**, *11*, 501. [CrossRef]
7. Bakiyeva, M. Выбрасывать Запретили, а Что Делать Не Сказали: Экокодекс Усугубил Проблему Стихийных Свалок в Казахстане. *Liter.kz*. 2022. Available online: https://liter.kz/vybrasyvat-zapretili-a-chto-delat-ne-skazali-ekokodeks-v-kazakhstane-usugubil-problemu-stikhiinykh-svalok-1658226388/ (accessed on 5 September 2023).
8. Ministry of Justice of Republic of Kazakhstan. *Ecological Codex of Republic of Kazakhstan*; Parliament of Republic of Kazakhstan: Astana, Kazakhstan, 2021.
9. CEAP. *A New Circular Economy Action Plan: For a Cleaner and More Competitive Europe*; European Commission: Brussels, Belgium, 2020.
10. Eurostat Circular Economy Monitoring Framework Platform. 2022. Available online: https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework (accessed on 10 April 2023).
11. Moschen-Schimek, J.; Kasper, T.; Huber-Humer, M. Critical review of the recovery rates of construction and demolition waste in the European Union—An analysis of influencing factors in selected EU countries. *Waste Manag.* **2023**, *167*, 150–164. [CrossRef] [PubMed]
12. Government of the Republic of Kazakhstan. *Об Утверждении Классификации (Таксономии) "Зеленых" Проектов, Подлежащих Финансированию Через "Зеленые" Облигации и "Зеленые" Кредиты [On the Approval of the Classification (Taxonomy) of "Green" Projects Subject to Financing through "Green" Bonds and "Greeen" Credits]*; Government of the Republic of Kazakhstan: Astana, Kazakhstan, 2021.
13. Turkyilmaz, A.; Guney, M.; Karaca, F.; Bagdatkyzy, Z.; Sandybayeva, A.; Sirenova, G. A comprehensive construction and demolition waste management model using PESTEL and 3R for construction companies operating in Central Asia. *Sustainability* **2019**, *11*, 1593. [CrossRef]
14. Bureau of National Statistics. Bureau of National Statistics of Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. 2023. Available online: https://stat.gov.kz/en/ (accessed on 19 May 2023).
15. SalimovaTekay, J. *Infrastructure Financing in Kazakhstan*; MPFD Working Paper Series, No. WP/22/02; ESCAP: Bangkok, Thailand, 2021.
16. Asian Development Bank. *Solid Waste Management Improvement Project (RRP UZB 45366)*; Asian Development Bank: Manila, PH, USA, 2013.
17. International Trade Administration. Uzbekistan Waste Management. 2019. Available online: https://www.trade.gov/market-intelligence/uzbekistan-waste-management-opportunities (accessed on 10 December 2023).
18. ZAWYA. Tadweer Signs Partnership Agreement with Uzbekistan's Ministry of Ecology, Environmental Protection and Climate Change. 2023. Available online: https://www.zawya.com/en/press-release/companies-news/tadweer-signs-partnership-agreement-with-uzbekistans-ministry-of-ecology-environmental-protection-and-climate-change-c0z0vyj4 (accessed on 10 December 2023).
19. Nippon Koei Co., Ltd. *Issyk Kul Sustainable Development Project*; Nippon Koei Co., Ltd.: Tokyo, Japan, 2009.
20. UNDP in Kyrgyz Republic. Let's Clean Kyrgyzstan's Waste—The Results of UNDP's Eco-Competition Announced. 2021. Available online: https://www.undp.org/kyrgyzstan/news/lets-clean-kyrgyzstan's-waste-results-undp's-eco-competition-announced (accessed on 10 December 2023).
21. Tleuken, A.; Tokazhanov, G.; Jemal, K.M.; Shaimakhanov, R.; Sovetbek, M.; Karaca, F. Legislative, Institutional, Industrial and Governmental Involvement in Circular Economy in Central Asia: A Systematic Review. *Sustainability* **2022**, *14*, 8064. [CrossRef]
22. Gigli, S.; Landi, D.; Germani, M. Cost-benefit analysis of a circular economy project: A study on a recycling system for end-of-life tyres. *J. Clean. Prod.* **2019**, *229*, 680–694. [CrossRef]
23. World Bank. *Discounting Costs and Benefits in Economic Analysis of World Bank Projects*; World Bank: Bretton Woods, NH, USA, 2016.